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BNC Seminar

2D Transition Metal Carbides and Nitrides (MXenes): Advances, Challenges, and Opportunities

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Bio: Babak Anasori is an Assistant Professor in the Department of Mechanical and Energy Engineering at Purdue School of Engineering and Technology in IUPUI. He received his PhD at Drexel University in 2014 in Materials Science and Engineering, the birth place of MXenes. Babak is one of the co-inventors of ordered double-transition metal MXenes, as a result of his postdoctoral research. His current research focuses on synthesis and characterizations of novel MXenes and their composites. He has co-authored over 100 refereed publications and has received several national and international awards for his research and artistic way of presenting science including NSF/Science Visualization Challenge in 2011 and 2013, Diamond ranking in ACerS Graduate Excellence in Materials Science (GEMS) in 2012, and Materials Research Society (MRS) Postdoctoral Award in 2016. Babak has originated and organized multiple international student competitions, including NanoArtography and Science in Video (SciVid) in the MRS Fall Meetings.

Abstract: Two-dimensional (2D) transition metal carbides and nitrides, called MXenes, are becoming one of the largest family of 2D materials with more than thirty synthesized compositions [1]. MXenes have shown outstanding performance in many applications including energy storage, catalysis, electromagnetic interference shielding, wireless communication, water purification, sensors, reinforcement in composites, and biomedical applications. In MXenes, n+1 layers of an early transition metal (such as Ti, V, Nb, Ta, Mo, Cr) cover n layers of carbon or nitrogen (n = 1–3), such as Ti2C, Mo2C, Ti3C2, Ta4C3. These 2D metal carbide flakes are covered with surface terminations, such as hydroxyl, oxygen, or fluorine, which add hydrophilicity to MXene surfaces [2]. Most of the synthesized MXenes to date, have high electrical conductivities (e.g., ~10,000 S/cm for Ti3C2), and high elastic properties. For example, the measured Young's modulus of a Ti3C2 single flake is ~330 GPa, which is the highest among the values reported for other solution-processed 2D materials, including graphene oxide.

MXene compositions can be further tuned by the formation of in-plane and out-of-plane atomic ordering when using two transition metals. For example, in Mo2TiC2 a layer of Ti atoms is sandwiched between two layers of Mo in a 2D carbide structure [3]. Such atomic orderings create a significant possibility of tunable 2D compositions, where properties, including electrical, electrochemical, and mechanical, can be tailored at the 2D level. In this talk, I will describe the advances and challenges in the synthesis and fundamental understating of MXenes with a focus on ordered double-transition metal MXenes and present an outlook for several opportunities in this large family of 2D materials.